Absorption of Carbon Dioxide by the Application of Carbonic Anhydrase. IV : Effect of Enzyme on the Rate of Absorption of Carbon Dioxide by Sodium Carbonate under Pressure

Absorption of Carbon Dioxide by the Application of Carbonic Anhydrase. IV

Effect of Enzyme on the Rate of Absorption of Carbon Dioxide by Sodium Carbonate under Pressure*

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Synopsis

Carbonic anhydrase accelerated the rate of absorption of carbon dioxide by sodium carbonate up to 19.87 atm., but the enzyme action decreased with the pressure. Following results were obtained at 10.87 atm. The rate of absorption increased with the concentration of the enzyme up to 100 mg/l and also increased with the elevation of the reaction temperature between 20.6° and ca. 40°C, whether the enzyme was present or not, but the enzyme lost its activity at 46.5°C. The effect of the enzyme was almost independent of the concentration of sodium carbonate. Red blood corpuscles (ox), used instead of the enzyme, increased also the absorption velocity.

I. Introduction

The absorption of carbon dioxide is one of the important manipulations in the chemical industry. As absorbents, water, caustic alkalies and many amines are used.

In the case, the absorption mechanism is very complex, because not only it depends on the state of the boundary film but also on the velocity of chemical reaction. As factors concerning to the absorption velocity by caustic alaklies or alkali carbonates, the viscosity and the surface tension, etc. of the solution were mentioned. For accelerating the absorption velocity, the addition of the following compounds were tried: Glycerol, dextrose, saccharose, pepsine, gelatine, peptone, ethylene glycol, levulose, methyl alcohol, ethyl alcohol, lactose, formaldehyde, soap, sodium lactate, triethylamine, and isopropanol, etc[1]. The author has observed that the absorption velocity of carbon dioxide by sodium carbonate was accelerated by the addition of carbonic anhydrase[2], which was also effective in the absorption of carbon dioxide by magnesium oxide[3] under pressure. In this study, the effect of the enzyme on the absorption velocity of carbon dioxide by sodium carbonate under pressure were measured.

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(1) Riou and the co-workers, Compt rend., **174** (1922), 1017, 1463, **184** (1927), 325, (1928), 1543, 1727; D. H. Killefer, Ind. Eng. Chem., **29** (1931), 1293; K. Fujinawa, J. Soc. Chem. Ind. Japan, **52** (1950), 39.

(2) K. Uchigasaki and R. Hara, J. Soc. Chem. Ind. Japan, **50** (1947), 106.

(3) K. Uchigasaki, Sci. Rep. RITU, **6** (1954) 402.

II. Materials, Experimental apparatus and manipulation

Materials

The same carbonic anhydrase used in the experiment of the second report[4] was used. Sodium carbonate of the commercial first grade quality was used and the concentration of the solution was determined by titration.

Experimental apparatus and manipulation.

The apparatus used in the experiment of the third report was used by the same manipulative method.

III. Experimental results

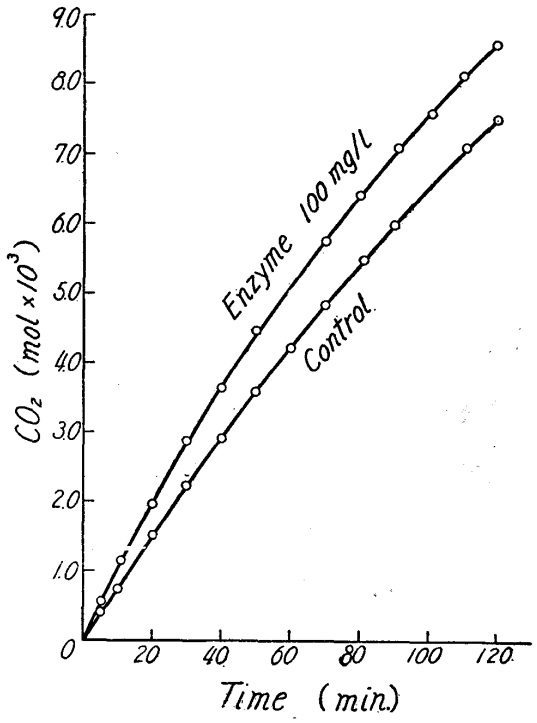

Fig. 1. Rate of absorption.

Some of the experimental results are shown in Fig. 1. It was perceived that carbonic anhydrase accelerated the absorption velocity of carbon dioxide by sodium carbonate under pressure. As in the case of magnesium oxide, by comparing dW/dt after 30 min. from the beginning of the reaction, the effect of carbonic anhydrase was examined.

(1) The effect of the concentration of the enzyme.

The effect was measured at the following conditions: The concentration of sodium carbonate, 1.5 N; the pressure of carbon dioxide, 10.87 atm.; and the reaction temperature, 20.6°C. As in the case of magnesium oxide, the absorption velocity increased with the increase of the concentration of the enzyme up to 100 mg/l, but further increase had little effect. The results were shown in Fig. 2.

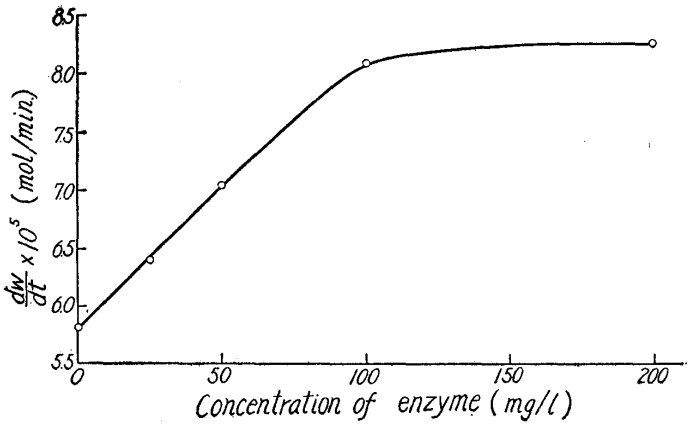

Fig. 2. Effect of concentration of enzyme.

(2) The effect of the concentration of sodium carbonate.

The effect was measured at the following conditions: The reaction temperature, 30.7°C; the pressure of carbon dioxide, 10.87 atm. and the

(4) K. Uchigasaki, S. Yokozeni and T. Toriumi, Sci. Rep. RITU, **6** (1954), 396.

concentration of sodium carbonate, 1.0~2.5 N. The absorption velocity was almost constant at the concentration of sodium carbonate between 1.0 N and 1.9 N. At the concentration of 2.5 N of sodium carbonate, a solid was formed at the contacting surface between the solution and the gas and floated on the surface, by which the absorption velocity in case of absence of the enzyme decreased. The enzyme was almost not influenced by the concentration of the carbonate. The results were shown in Fig. 3.

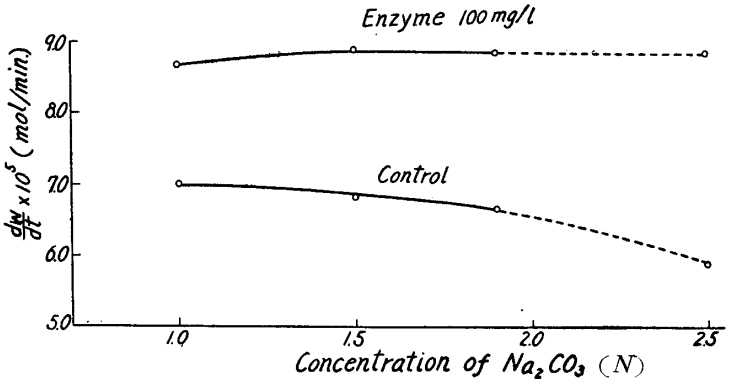

Fig. 3. Effect of concentration of Na_2CO_3.

(3) The effect of the temperature.

In case of the concentration of sodium carbonate was 1.5 N and the pressure of carbon dioxide 10.87 atm, the absorption velocity increased with the elevation of the temperature, but the effect of the enzyme decreased and was lost at 46.5°C. Comparing with the case of the ordinary pressure, the temperature at which the enzyme lost its activity was lowered by 3.5°C. The results were shown in Fig. 4.

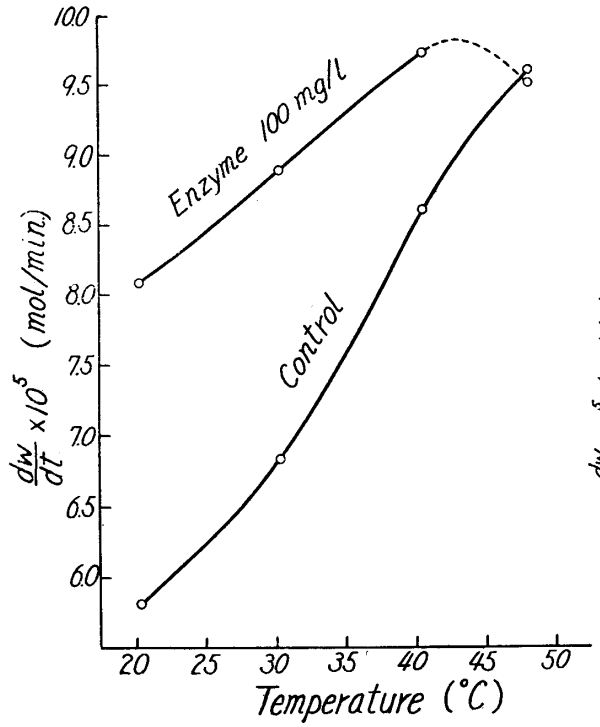

Fig. 4. Effect of temperature.

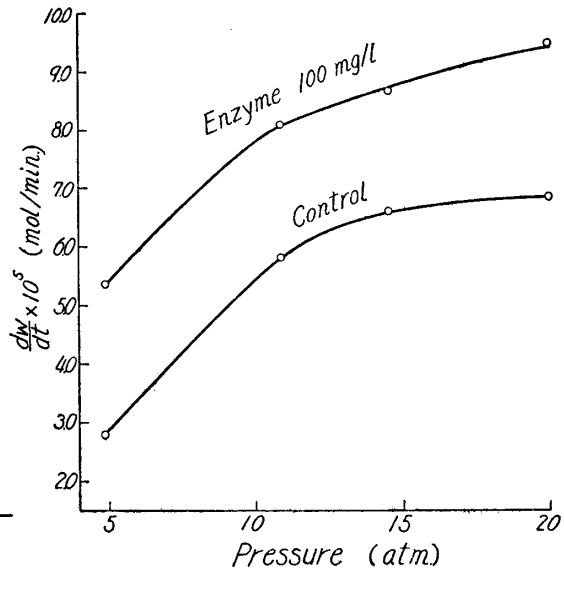

Fig. 5. Effect of pressure.

(4) The effect of the pressure.

The effect was measured at the following conditions: The concentration of sodium carbonate, 1.5 N; the reaction temperature, 20.6°C; and the pressure, 4.87 ~19.87 atm. As shown in Fig. 5, the absorption velocity increased with the in-

crease of the pressure, which decreased the effect of the enzyme.

(5) The effect of the addition of the red blood corpuscles.

By the above results, it was perceived that the enzyme was effective for increasing the absorption of the carbon dioxide by sodium carbonate under pressure. Then the effect of the red blood corpuscles was examined without separating the enzyme. As described in the second report, fresh ox blood was mixed with a quarter volume of 3.8 per cent sodium citrate solution for preventing coagulation and separated from the serum by a centrifugal machine and then washed three times with a physiological solution of salt. The concentration of sodium carbonate was so regulated to be 1.5 N when the red blood corpuscles were added. The results were shown in Fig. 6. As the red blood corpuscles contained many substances, it was feared that these substances may give some effect on the absorption velocity by changing the surface tension or viscosity, etc. of the solution of sodium carbonate. The experiment was, therefore, conducted by adding sodium cyanide (concentration: 2 g/l), which was a strong hindrance for carbonic anhydrase. The result was almost same with the case of absence of the enzyme. It was, therefore, concluded that the substance accelerating the absorption velocity was only carbonic anhydrase.

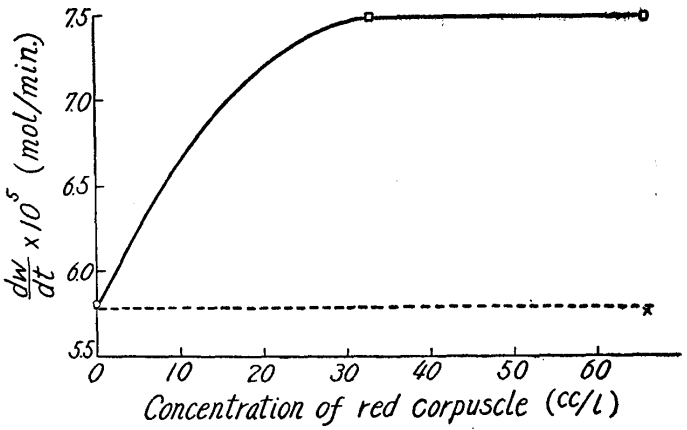

Fig. 6. Effect of concentration of red corpuscle.
○ Control □ Red corpuscle
× Red corpuscle 66.6 cc/l + NaCN 2 g/l

Conclusion

Carbonic anhydrase accelerated the absorption of carbon dioxide by sodium carbonate under pressure at the concentration of 1.0~2.5 N and up to 10.87 atm. The effect of the enzyme was almost independent of the concentration of sodium carbonate but decreased with the elevation of the pressure. It also decreased with the elevation of the reaction temperature. The enzyme lost its activity at 46.5°C. The red blood corpuscles also accelerated the absorption velocity.

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